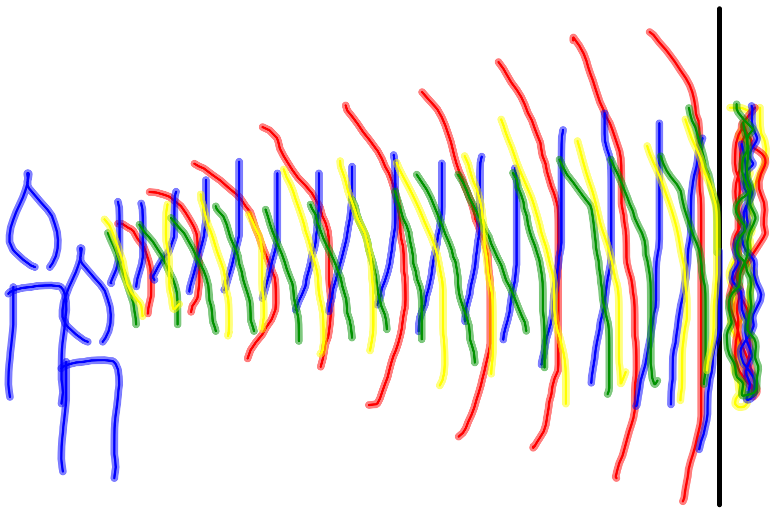
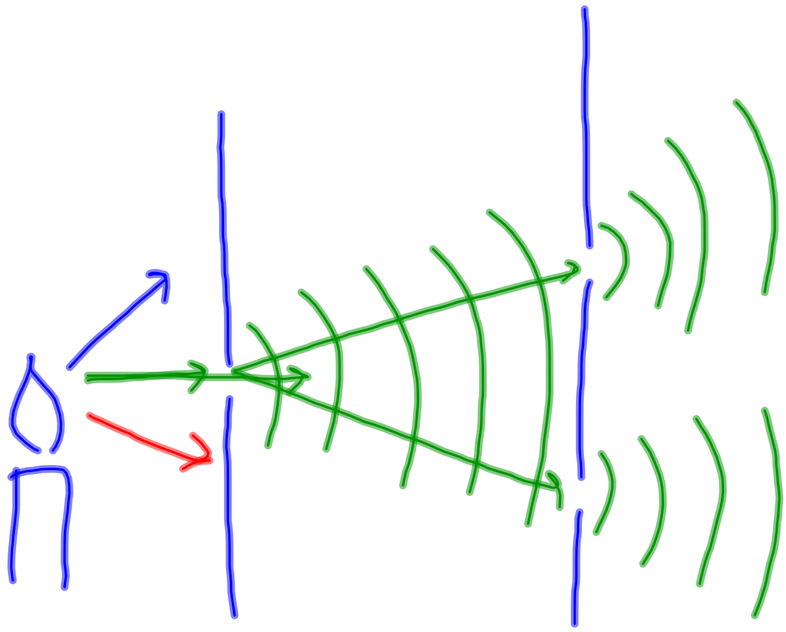
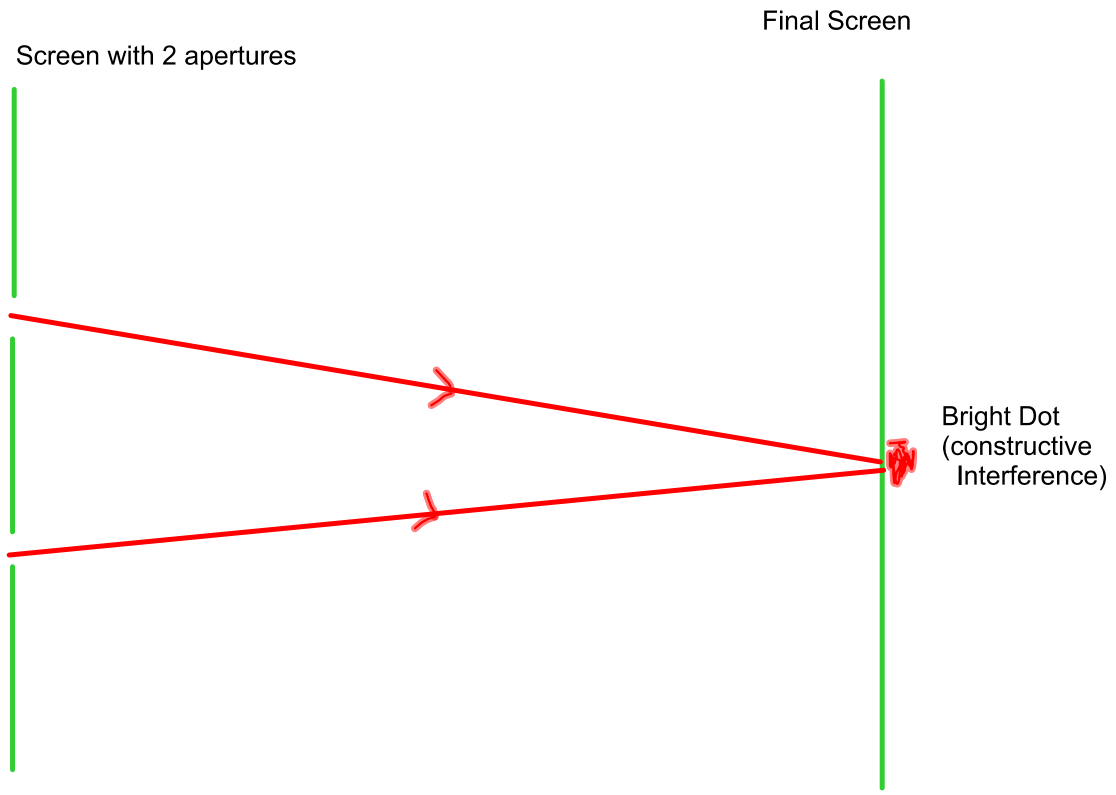


Many scientists had tried to show an interference pattern using two candles and observing the resulting light on the screen. The problem is that the candles emit a mishmash of rays with different wavelengths and phases, producing only a wash of light on the screen and no noticeable pattern.



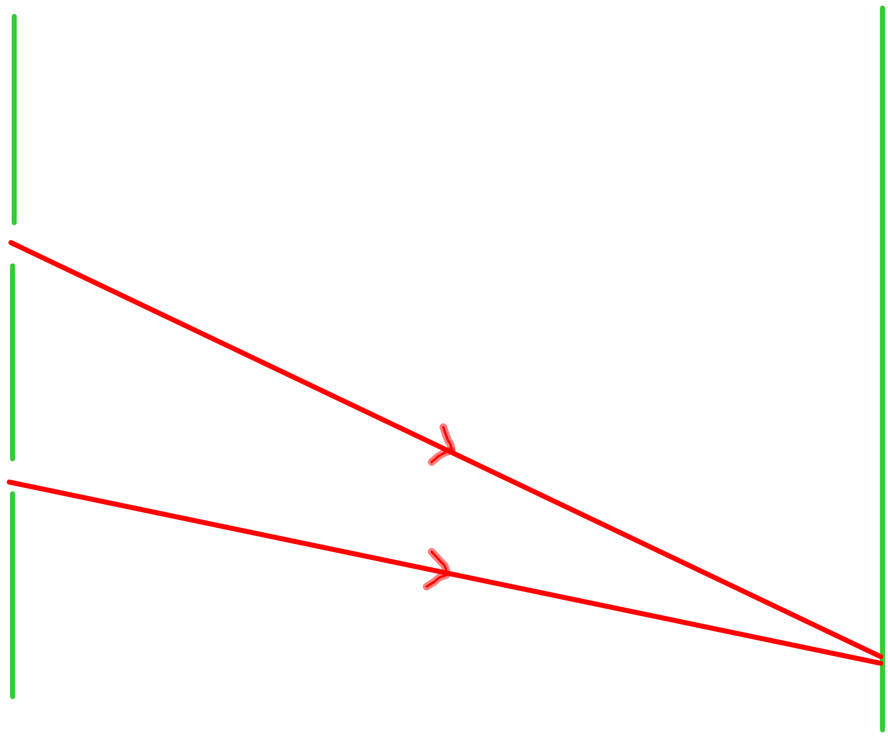
Thomas Young's experiment used one candle and a series of pinholes to ensure that only one wavelength of light would be used.

Light from the candle strikes the first screen. A small aperture (pinhole or slit cut from a razor blade) allows only one ray (or a small number of rays) through. This light ray spreads (diffracts) as it leaves the first aperture, striking two holes in a second screen. The light leaving these two pinholes is therefore coherent (same wavelength, same phase). Now if they interfere, it will be easy to see a pattern of bright spots (constructive interference) and dark spots (destructive interference) on a third screen.



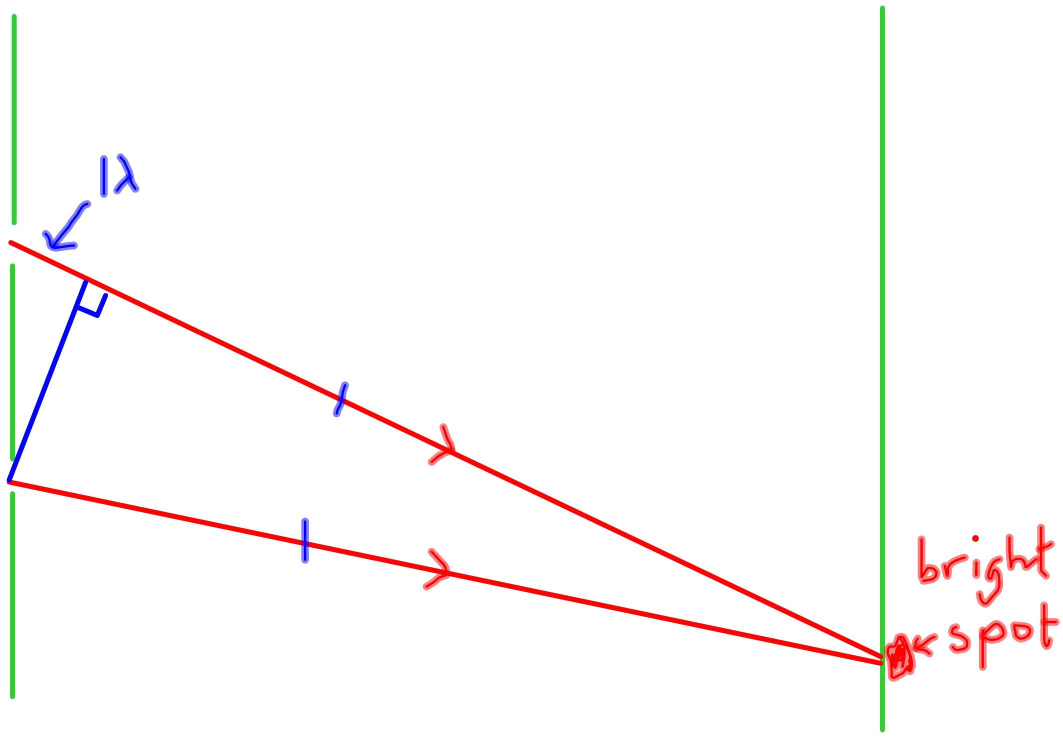
Thomas Young used basic geometry to calculate an approximate value for the wavelength of light.

Consider two rays of light that strike the far screen in the middle.
Both rays travel the same distance. Both rays began in phase.
Therefore both rays meet in phase on the screen.
This means there will be a central dot of bright light on the screen due to constructive interference.

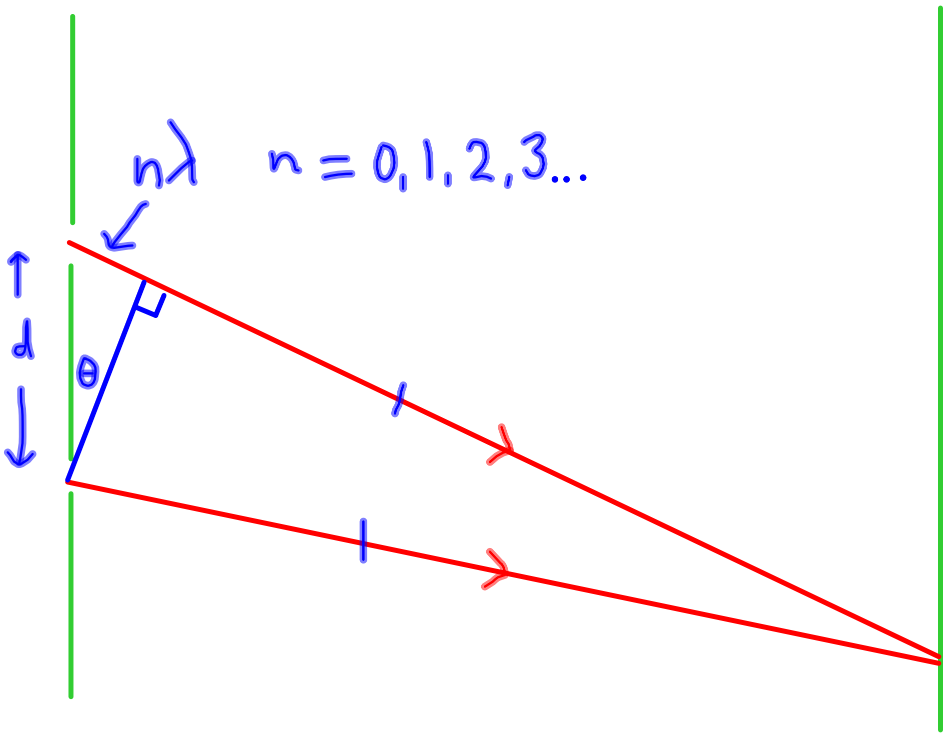


Now consider two rays of light that hit the screen off centre.
Can the rays constructively interfere here too?
The top ray is longer than the bottom ray. If it is longer by **exactly one wavelength**, then we will get constructive interference.

path difference = 1 wave

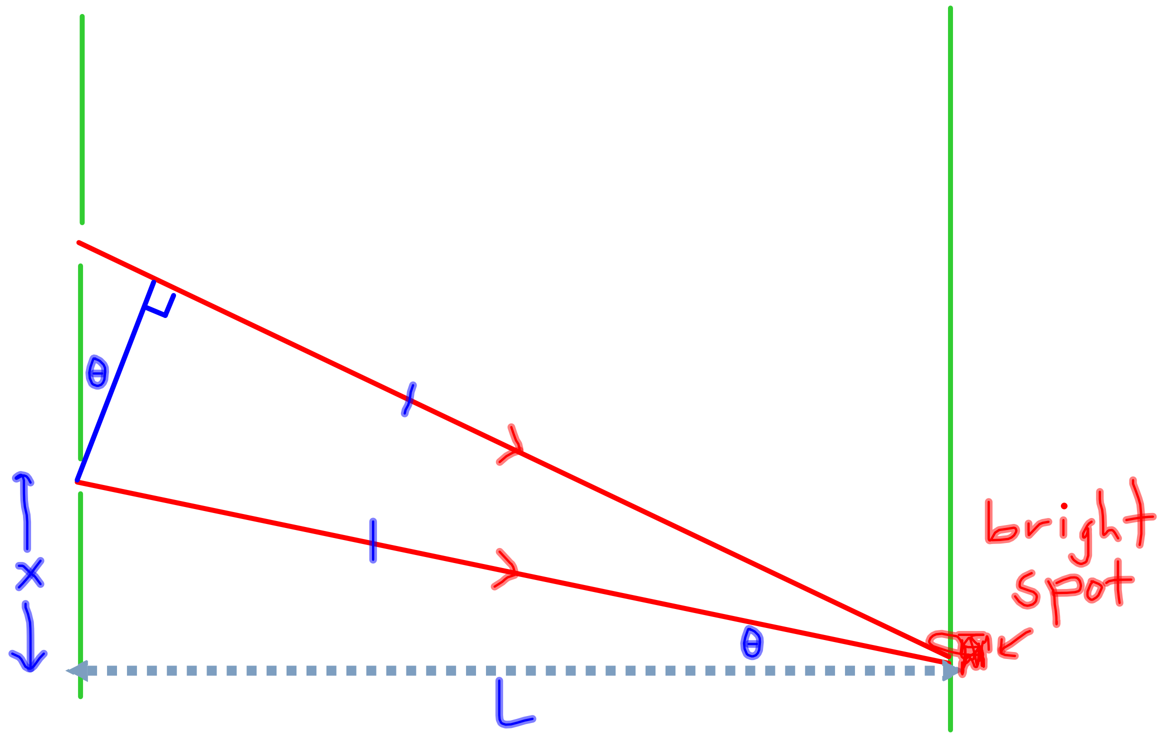


We cut a segment from our upper line to make it equal to the lower line. The line that cuts it will cross at almost 90 degrees (the longer the distance to the screen the more it will be close to 90 degrees).
For constructive interference, the extra path the upper ray takes must be 1 wavelength long.



For constructive interference where the rays meet, the path difference can be 0, 1, 2, 3 wavelengths. As long as it is a whole number of wavelengths, they will meet in phase.
If we call the distance between the slits "d", we get:

$$\sin\theta = \frac{n\lambda}{d}$$



Drawing the length L between the slits and the screen, we create a new larger triangle which is similar to the small triangle.
If we let x be the vertical distance from the slits to the bright spot on the screen, then:

$$\tan\theta = \frac{x}{L}$$

So far we have:

$$\sin\theta = \frac{n\lambda}{d} \qquad \tan\theta = \frac{x}{L}$$

To put them together, we make one final approximation:
For small angles (less than 2 degrees or so), sine and tangent are roughly equal.

This gives us Young's Approximation:

$$\frac{n\lambda}{d} = \frac{x}{L}$$

$L = 4.3m$

$X = 1.5\ cm$

$n = l$

$d = 0.01mm$

$\lambda = ?$

$(\lambda = 3.5 \times 10^{8}\ m)$

Ex.

$L = 4.3m$

$d = 0.01mm$

$n = 1$

$X = 0.8\ cm$

$\lambda = \frac{dx}{nL}$

$= \frac{(0.01 \times 10^{-3})(0.8 \times 10^{-2})}{1(4.3)}$

$\lambda = 1.8 \times 10^{-8} m$

Visible Spectrum

Infra Red ←

R O Y G B V

→ Ultra Violet

750nm

400nm

long λ

←

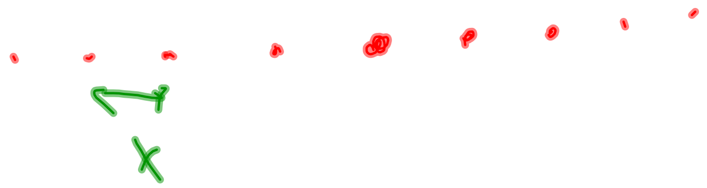
(low f)

short λ

→

(high f)

Ex I shine yellow light (600nm) on a 2-aperture (razor slit) screen onto a screen 4.5m away. The distance between dots is 2.2cm. Find the distance between the razor slits.



1.2×10^{-4} m (0.12 mm)